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Time-Charter Rates*

by

Zenon S. Zannetos

Sloan School of Management
Massachusetts Institute of Technology

Working Paper 272-67

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Zenon S. Zannetos*

The purpose of this paper is to analyze the factors which affect the level and structure of time-charter rates. The analysis will be divided into two major parts:

I. Concentrating on the factors determining time-charter rates in the short-run, i.e. with technology and size-composition of the fleet remaining approximately constant, and

II. Modeling the impact of various long-run factors on time-charter rates, such as changes in the size composition of the tanker fleet, uncertainty with respect to full-time employment and full-cargo utilization of large vessels, and changes in operating costs.

I. Time-charter Rates in the Short-run

In The Theory of Oil Tankship Rates[1] evidence was presented that time-charter rates for the period 1949 through 1959 were mainly affected by the:

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[1]Zannetos, Zenon S., The Theory of Oil Tankship Rates: An Economic Analysis of Tankship Operations, MIT Press, April, 1966.

1. Size of the chartered vessel (reflecting economies of size, i.e. cost of shipbuilding and ship operation)
2. Level of spot rates at the time of the transaction
3. Duration of the charter agreement
4. Lead-time from the point of transaction to delivery

The conclusion was also reached at the time that, in general, normal costs,[2] more than any other factor, dominated the determination of time-charter rates. The relationship between normal costs and time-charter rates was found to be stronger the longer the duration of the charter agreement. With the changes in technology in the tankship industry and the size composition of the operating fleet that we are witnessing, these relationships are expected to be even stronger. Therefore, the structure of rates during the period of 1959 to 1966 should exhibit greater variation than it did in the past.

Another conclusion that emerged out of the 1949-1959 analysis was that the spot rate affects the level of time-charter rates as well as the duration of the agreement and the lead-time between the point of transaction and delivery of the vessel. Because short-term market conditions affect expectations about the future, when spot rates were high so were the time-charter rates and the longer were the duration of the agreements and lead times. The combined impact of normal costs and spot rates caused the level of time-charter rates to converge asymptotically to the normal rate (normal cost) from both above (when

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[2]We define as normal cost the time-charter rate (normal rate) which will, over the life of the vessel, return to the owner 8% on his investment after taxes (using discounted cash-flow analysis).

the spot rate was greater than the normal rate) and below (when the spot rate was lower than the normal rate) as the duration of the contract increased.[3]

Among our objectives under this section is to determine whether the above conclusions of 1959 are still valid today, and measure the impact of the various factors affecting time-charter rates.

During the period from December 1959 to December 1966 we recorded a total of 297 observations,[4] and subjected them to multiple regression analysis. The variables used are as follows:

X_1 = size of vessel in DWT

X_2 = spot rate for the marginal vessel + 100 Intascale points (we add 100 to convert the rate to a positive figure, e.g. Intascale minus 40 is recorded as 60)

X_3 = duration of the contract in months

X_4 = delivery lead time in months

X_5 = spot-rate equivalent of the time-charter rate + 100 Intascale points

X_6 = X_5 as above minus the spot-rate equivalent of the break-even time-charter rate of the chartered vessel + 100 Intascale points

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[3]For more on this see The Theory of Oil Tankship Rates, op. cit., Chapter 9.

[4]This figure represents the total number of transactions recorded by the following tankship brokers (excluding duplications of course): Davies and Newman, Howard Holder, Ltd., and Conrad Boe.

The size (X_1) is included among the independent variables in order to record the impact of the economies realized by large vessels.

As we have already explained X_2, the level of spot rates at any moment of time, influences expectations about the present and the future market conditions, and therefore we may hypothesize that after it goes outside a critical range, it affects the level of time-charter rates. Realizing that in the spot market we have a whole structure of rates due to the various sizes of vessels operating therein (i.e. we do not have, especially now, a single rate which is applicable to all sizes of vessels) we decided to pick out a marginal vessel[5] weekly, and use its rate as representative of normal spot-market conditions for that week. In this way we hope to succeed in reducing the correlation between the particular level in spot rates and the spot rate of vessels reflecting economies of size,[6] so that we can better measure the impact of the latter (X_1).

The variables X_3, and X_4 are straightforward as well as the reasons for their inclusion in the model. In the past both affected the time-charter rates in the same manner. When market conditions were good the longer the duration of the contract and lead time the lower was the time-charter rate. Under depressed market conditions the opposite was observed.

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[5]A marginal vessel is defined as the smallest vessel chartered in the spot market for the run under consideration during the week in which the time charter was transacted, and which is not a special purpose vessel.

[6]Extensive tests were conducted during which the marginal vessels were chosen such that the spot-rate deviations from these marginal spot rates for all vessels chartered in the spot market were almost completely uncorrelated with the level of marginal spot rates.

The spot equivalent of the time-charter rate (X_5) is one of two dependent variables we will be testing, the other being X_6. The latter is the difference between the spot-rate equivalent of the actual time-charter rate (i.e. X_5) and the theoretical rate which would have given the owner of that particular vessel an 8 per cent return after taxes under conditions of normal employment for twenty years, 50 per cent tax rate, use of the sum-of-the-years' digits method for depreciation, and financing the vessel by borrowing 80 per cent of the total cost at 6 per cent per year for eight years. In effect the theoretical rate may be thought of as the spot-rate equivalent of the break-even time-charter rate of independent operators who expect an 8 per cent return on their investment after taxes. A selective list of some break-even time-charter rates used for the various years is provided in Table 1. The purpose of variable X_6 is to explain deviations from pure cost-based time-charter rates.

Analysis of the results

We will present here the results of mainly two computer runs. One depicting a non-logarithmic linear regression model and the other a logarithmic formulation. The correlation matrices and the regression equations are shown in Tables 2 and 3 for the non-logarithmic and Tables 4 and 5 for the logarithmic model. The first model (non-logarithmic) was then tested with stratified data (by level of spot rates and size of vessels chartered) and the results are shown in Tables 6, 7 and 8.

Certain characteristics of the data used for the analyses and which are

included in Table 2 reveal some interesting facts:

(a) The mean size of vessels chartered on long-term basis was only 50,292[7] DWT, with a standard deviation of 27,918 DWT. The size distribution of these vessels was skewed toward the smaller sizes and the spread around the mean was obviously asymmetric. The range beyond the mean was at least twice the size of that below the mean.

(b) The mean marginal spot rate and the mean spot-rate equivalent of the actual time-charter rate were within 3.1 Intascale points. The standard deviations, however, were quite different with that of the marginal spot rate being close to twice that of the time-charter rate. This supports our belief that the time-charter rates are influenced much more by objective factors than by the expectations as affected by short-term fluctuations in the spot-rates. In view of the great range in tanker sizes the similarity between the mean marginal spot rate and the mean time-charter rate (for a mean size of 50,000 DWT) leads us to conclude that market conditions during this period were rather good.

(c) The mean differential (X_6) (i.e. the differences between the actual time-charter rate and the theoretical rate) was surprisingly small. On the average the actual rate was only 2.74 points lower than the

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[7] This also reflects the fact that some large vessels are chartered on private terms.

theoretical indicating that the charterers on the average earn close to 8 per cent (discounted cash flow) return on their investment, after taxes. It also provides an empirical confirmation of our theoretical arguments that the most significant factor influencing time-charter rates is cost. The standard deviation of X_6 was 10.59 Intascale points.

(d) The average time-charter duration was 69.5 months but the variance was quite large. This may be due to heterogeneities in the size distribution of vessels chartered and if that is verified the data reveal possible differences in the duration of charters with different spot-rate levels. These hypotheses we will examine later.

Turning now to the zero-order correlation and the regression results listed in Tables 2 and 3 we notice that:

(i) Size is the single most important variable explaining charter rates (over 50 per cent of the variation). The greater the size the lower the rate as some of the economies of size are passed on to the charterer.

(ii) The impact of the marginal spot rate on other variables is very insignificant. Particularly we notice how small are the correlation coefficients between the marginal spot rate and size (X_1) and the rate differential(X_6). Given that also the

correlation between the marginal spot rate (X_2) and X_5 (the spot equivalent of the time charter) is very insignificant, we are led to conclude that for contracts such as those we are studying, (extending over 6 1/2 years on the average) the impact of spot rates is negligible. We must also point out, however, that the period we are studying although healthy was relatively calm. It did not exhibit the wild fluctuations in spot rates which occur at times of "crises" and which fluctuations would have undoubtedly affected expectation about the future and with the latter the level of time-charter rates.

(iii) The choice of 8% after taxes as the relevant average cost of capital seems to be supported by empirical evidence. This we conclude on the basis of the average size of X_6 and the relationship between X_2 and all the other variables. It must be remembered that the economies of scale are fully reflected in X_6. So to the extent that X_5 is relatively free from short-term impacts any difference between the actual and theoretical rate is due to the rate of return.[8]

(iv) The correlation coefficients (R) and the coefficients of determination (R^2) show that in explaining X_5, the contribution of

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[8]Impurities in the cost data would also affect X_6.

variables X_2, X_3 and X_4 is rather insignificant. This fact plus the observation that X_1 (size) is also the most important variable for explaining X_6 (it explains about 27 per cent of the variation in X_6, the difference between actual and theoretical rates) convinces us that we should concentrate on getting good cost data for any meaningful management information system in tanker chartering. We have noticed almost complete identity between X_5 and the theoretical break-even rate yet we now note that size explains approximately 27% of the variation in X_6. This implies that the larger vessels earn more than 8% return while the smaller vessels earn less. The subsequent stratification of the data by size of vessels provides evidence that this inference is justified.

(v) The regression equations point out that X_1 (size) operates on time-charter rates in two opposing directions. The greater the size of the vessel the lower the charter rate because some of the economies of size are passed on to the charterer. What proportion of these savings remains with the owner, however, depends upon how efficient his vessel is as compared to the average. Tables 2 and 3 provide empirical evidence that the larger vessels earn a higher rate of return. So in effect size affects the general level of time-charter rates negatively, but the relative structure positively. This can also be seen in the sign of the correlation coefficients between X_1 and X_5 (negative) and X_1 and X_6 (positive). These observations are in

complete agreement with theoretical formulations advanced previously[9] and which will also be used for our discussion under Part II.

(vi) With the exception of the regression coefficient of X_4[10] (which is opposite to the sign of the correlation coefficient between X_4 and X_5) the signs of all the correlation and the regression coefficients are as expected. The duration of the charter agreement and the charter rate are negatively related (although not strongly in the regression equation) showing that the spot rate for this period is if anything somewhat high relative to the "normal" time-charter rate of the vessels chartered. Also the lead time to delivery is negatively correlated with X_5 showing that its behavior is similar to that of charter duration. We also notice the results of some inter-correlation among "independent" variables, such as spot rate and duration of time charter agreements as well as lead times, which again are to be expected.

(vii) The positive correlation and regression coefficients between X_6

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[9]Zannetos, Zenon S., "Theoretical Factors Affecting the Long-Term Charter Rates for Tankers in the Long Run and Suggestions for Measurement" Sloan School of Management, MIT, Working Paper 118-65.

[10]This coefficient is statistically insignificant even at the 95% confidence level.

and X_3, and X_4 indicate that the larger the chartered vessels the longer the charter duration. In closing our discussion of the results of Tables 2 and 3 we wish to repeat that only the regression coefficients of X_1 are statistically significant. All the others are statistically insignificant even at the 95% confidence level, although in the right direction (except for X_4).

The logarithmic relationships are shown in Tables 4 and 5. Because X_6 (the difference between the actual and the break-even time-charter rate) ranges over negative values it was dropped from the logarithmic model and two alternative measurements were introduced. One, X_7, is based on the ratio of the actual to the theoretical time-charter rate, and X_8 is X_6 plus 35 Intascale points to shift its range over positive values.

The results of the logarithmic formulation are obviously better, and the reasons for this are firmly grounded in theory. Since expectations and discounting are by nature exponential functions, their impact on tanker rates will in turn follow exponential decay paths. Again from Tables 4 and 5 we observe that X_1 (size) stands out explaining 63 per cent of the variation in X_5 (the other three variables only adding 1.4 per cent to the total variance explained) and 47 per cent of the variation in X_7 (the rest adding less than 1 per cent to the total).

The regression equation for X_5 shows that the coefficient of X_2 (spot-rate level) is not important but all the other coefficients are statistically significant at the 98% confidence level. The signs of the coefficients of

X_1 and X_3 are consistent with those of the zero-order correlation coefficients but not the rest. In the case of X_2, given its instability and weakness, this ambivalence is understandable, but the only explanation we can find for X_4 is in the strong intercorrelation between lead time and the other variables (especially charter duration and size of vessel).

To test any differences in the behavior of time-charter rates with different levels of spot rates and also with different sizes of vessels, we stratified our data. We decided to designate anything below Intascale less 57% (the break-even time-charter rate of a 60,000 DWT vessel) as low rates, between Intascale less 57% and Intascale less 32% as medium rates, and finally anything over Intascale less 32% (the break-even time-charter rate of the smallest of the marginal vessels) as high rates. In terms of size we divided the data into two groups, one for vessels below 40,000 DWT and the other for vessels of 40,000 DWT and over.

Some of the results of our analysis are included in Tables 6, 7 and 8 and show that:

1. The average size of vessels chartered decreases as spot rates increase showing the entry of smaller vessels into the market. This relationship, however, becomes weaker at higher levels of spot rates indicating that beyond the break-even rate of the marginal vessel, the level of spot rates cannot affect the supply of tonnage in the short run. So by bidding up the rates under such circumstances, instead of providing relief, the charterers cause undesirable market conditions in the long run.

2. The duration of charter agreements is positively related to the size of the vessel, and so is the lead time. As Table 8 shows for vessels under 40,000 DWT the mean duration was 42.1 months and the mean lead time 6.3 months. For vessels of 40,000 DWT and over, however, the comparable figures are 97.5 and 13.3 respectively. The standard deviations are also significantly greater for vessels of 40,000 DWT and over. We also note (Table 6) that as the level of spot rates rises the correlations between charter duration and lead time versus size become stronger, indicating that the charterers are influenced by elastic expectations.[11] As a result (and paradoxically) the ownership of large vessels may in the long run be relatively less risky for the independents than the ownership of medium-sized vessels.

3. No matter what the level of spot rates, size and spot equivalent of time-charter rates are negatively correlated and size versus X_6 positively correlated. The first correlation appears to be strengthened as the level of spot rates increases revealing possible heterogeneities in the size composition of the vessels chartered, with relatively more small vessels chartered

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[11] For explanation of this phenomenon see: Zannetos, Zenon S., The Theory of Oil Tankship Rates, pp. 42-49 and 77-80.

during medium and high rates. This suspicion is further strengthened by the fact that the correlation between size (X_1) and the differential (X_6) reaches a peak with "medium" rates and drops extensively during "high" spot rates. A look at Table 8 (top part) reveals that the mean size of vessels chartered decreases as spot rates increase because of the entry of smaller vessels into the picture. We also notice that in spite of the fact that at high rates charter duration and spot rates are positively correlated the mean duration of contracts decreases from 87.58 months during "low" rates to 49.71 for the "high" rate period. This is definitely due to the size composition of the chartered vessels. During the "low" period 26 1/2% of the charters went to vessels under 40,000 DWT. The comparable figures for the "medium" and "high" periods are 43% and 50% respectively. In terms of charter duration, for vessels under 40,000 DWT 43% of the contracts were for five or more years and 4.6% for twelve or more years, whereas the comparable figures for vessels of 40,000 DWT and over are 57.5% and 29%. It is the net effect of these two factors (size composition and charter duration as related to the level of spot rates) which is reflected in X_5 and X_6 on the top part of Table 8. The bottom part of the latter provides further evidence to this effect.

4. During the period of "high" rates, Inta-32 and over, the size of vessels contracted was peculiarly distributed, either between 20,000-40,000 DWT or over 60,000 DWT. (mostly over 80,000.) For all sizes we notice as already mentioned a positive correlation between size and X_6 but when the rate goes beyond Inta-18 the large vessels of 80,000 DWT and over show a negative correlation. This shows that more and more of the economies of size realized by supertankers (as compared to the marginal vessels) are yielded to the charterers to compensate them for the inflexibilities and risks that they are shouldering. These risks we will attempt to measure in Section II. We must further add that with spot rates being relatively well behaved over the period we are studying (the highest level reached was Intascale plus 3%) the number of observations obtained at "high" rates is only 25.

5. The signs of the correlation coefficients between X_3 and X_4 (charter duration and lead time) versus X_2 (spot rate level) which change from positive to negative and back to positive as rates go from "low" to "medium" to "high" provide further evidence that elastic expectations operate in the tankship markets.

6. At very low rates the duration of charter agreement (and lead time) and time-charter rates are positively correlated but at high rates are negatively correlated. This is in complete

agreement with the theory that is fully developed elsewhere.[12]

7. The spot rate is critical for small vessels in order to encourage them to stay in the market. Thus there is a significant positive correlation between the level of spot rates and time-charter rates as well as X_6 for small vessels. This is not so for the large tankers.

8. The size stratification of the data understandably destroys the predictability of the models and points out once again the significance of the economies of size in determining time-charter rates.

9. The negative relation between spot rates and time-charter rates for large vessels and at high rates is rather peculiar, although not statistically significant. Unless of course it reflects the impact of turning points in expectations.

10. As the lower part of Table 8 shows not only the rates are extensively influenced by cost but also the charter duration and the lead time. Another significant observation is that the market develops its own notion as to what the marginal and normal vessels are over the average duration of the contracts. An analysis of the differences between X_2 and X_5 shows that for the period under review the average marginal vessel was expected to be 38,000 DWT and X_6 reveals that the average normal vessel was thought to be

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[12]Ibid, pp. 202-214.

about 55,000 DWT. For vessels below 55,000, X_6 is expected to be negative but for those above, positive reflecting the fact that some of the ever increasing efficiency premiums of larger vessels remain with the owners.

II. Model for Determining Time-Charter Rates in the Long-Run

We will now use our knowledge of the time-charter market to develop and test a model for determining time-charter rates for the long run. The model used is quite elaborate and it is extensively described in "Theoretical Factors Affecting the Long-Term Charter Rates for Tankers in the Long Run and Suggestions for Measurement."

It is based on the premises that:

1. The projected normal spot rate[13] over the duration of the contract serves as the point of departure for the determination of the relevant time-charter rate.
2. The owner of a vessel by means of a time-charter agreement shields himself from certain vagaries of the spot market, and shifts certain risks to the charterer. Adjustments, therefore, must be made to encourage the charterer to shoulder these risks.
3. The factors which necessitate adjustments from such normal spot rate are:

   (a) The risk of underemployment of the chartered vessel,

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[13]This is the rate which will provide an 8% return after taxes to the owner of the fictitious vessel which is continuously marginal during the time-charter agreement.

because of its size. Often large vessels have to be loaded only partially and also require an extensive coordinative system to overcome the inflexibilities of their size. The charterer, therefore, should expect some concessions for these inflexibilities.

(b) The risk of unemployment. A vessel which operates in the spot market is subject to frictional unemployment, and sometimes extensive periods of idleness due to market conditions. The normal spot rate, therefore, is adjusted to reflect the probability of unemployment, if reinvestment in tankers is to be guaranteed. Once a vessel is chartered for an extended time period, the risk of unemployment is shifted to the charterer and the owner is guaranteed a fixed rental. The charter rate, as a result, will reflect this shift.

(c) The savings in brokerage fees, if any, that the owner will realize because he does not have to resort to the spot market over the duration of the charter agreement.

(d) The loan value of the charter agreement. If the owner of a vessel holds a charter contract, he can obtain mortgage money for building vessels and for operating them. In addition to enabling the owner to be in the industry in some cases, the loan allows the owner to trade on the equity and, therefore, realize a higher

return on his own investment than he would have otherwise realized.[14] For example, the break-even time charter rates listed in Table 1 would have yielded approximately 5.6% rather than 8% return on investment had the owner used 100% equity financing. Under these circumstances, the owner, if fully loaned, would be glad to cede part of his gain to the charterer in order to obtain a long-term contract.

(e) The efficiency premium of the particular vessel. To the extent that certain costsfall upon the charterer under a time-charter agreement and therefore are variable[15] (such as fuel oil) any projected change in these costs will affect the cost of the charterer. If, as a result, an increase in costs is projected, then the vessel which is more efficient in the utilization of that resource should merit a premium. This variable is aimed at taking care of such eventualities and is added on the normal spot rate.

A. Measurement of the above variables (all translated into spot-rate equivalent)

1. The risk of underemployment is measured in terms of the cost savings due to economies of size. We first obtain the break-even time-charter

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[14]This will be true as long as the interest rate is lower than the average return realized on the total assets invested.

[15]All other variable costs and projected changes are considered in the calculation of the normal spot rate.

rate for the chartered vessel, and also for the marginal vessels at both the point of transaction and the point of termination of the contract. Then we hypothesize that the total amount subject to bargaining is composed of:

(a) the economies-of-size advantage of the chartered vessel over the vessel expected to be marginal at the point of termination of the contract, plus

(b) a part of the economies-of-size advantage of the marginal vessel at the point of termination of the contract over the marginal vessel at the point of transaction.

A further assumption is made that the duration of the contract will determine what part of (b) above is granted to the charterer. So an exponential decay function is applied to grant all but 5% for a 15-year time charter.

2. The total cost of the risk of unemployment is that extra amount which must be recovered over the time a vessel is employed, to compensate for the periods of unemployment. This is in order that the owner will achieve an 8% average return on investment. Again here we assume that the owner will be willing to yield to the charterer close to the total (95%) if he is guaranteed the security of a 15-year time charter. For charters of shorter duration we read the amounts out of an exponential decay function.

3. In order to determine the brokerage-fee savings, we assume that the fee can be reduced from a normal 2 1/2% of the total rental to 3/4 of 1%.

The formula which determines what part goes to the charterer is exponential and combines both the size of the vessel and the time-charter duration.

4. The loan-value of the charter agreement is based on the difference between a "restrictive" and a "liberal" loan plan for financing the cost of a new vessel. The "restrictive" plan assumes that the owner must put down 25% of the total cost of the vessel and borrow the rest (75%) at 6% per year for 8 years. In contrast the "liberal" plan, which assumes a time-charter agreement as a collateral, provides for a down payment of only 10% and a twelve-year loan for the rest (90%) at 5% per year for twelve years. The cost of these two plans is calculated by assuming a cost of capital of 8%, and the difference between the two plans is attributed to the charter agreement. As in the case of the other calculations we assume that exponentially 95% of the loan-value of the charter agreement is conceded to the charterer as the duration of the contract approaches 12 years.

5. In the calculations that we present here in Tables 9, 10 and 11, the efficiency premium is based on the assumption that fuel-oil costs will rise at 1% per year. The more efficient, therefore, a vessel is in oil consumption the greater the premium it will merit in the market. If it is assumed that costs are expected to remain the same this variable can be dropped without affecting the rest.

B. Analysis of the results

Before we present the results that we obtained by using this model, we must

stress that the operating data, especially for the largest tankers, were provided to us by Japanese sources and are mostly based on estimates. Operating experience with the largest tankers is still in the future. But any impurities in the data do not damage the usefulness of efforts such as ours. The most important part of such efforts lies in the theoretical development of the model. If better data are available or if a person wishes to test different plans on the basis of hypothetical data, the model is flexible enough to derive the consequences and present them to the manager for his attention.

Tables 9, 10 and 11 show some of the results which can be obtained by using the aforementioned model for three different tanker routes. It is assumed that a vessel of the sizes shown in the first column will be chartered for 15 years[16] at a time t_o when the marginal vessel is 45,000 DWT for the Persian Gulf-United Kingdom and the Caribbean-United Kingdom runs, and 75,000 DWT for the Persian Gulf-Japan run. At t_{15} (the termination of the contract) the marginal vessels for the three runs are assumed to be 100,000, 100,000 and 150,000 DWT respectively.

The model develops the average normal spot rate during the charter period and proceeds to adjust it for the impact of variables X_1 through X_5. For reasons previously explained, if the owner foresees full-time employment with absolute certainty, then he will not be willing to pass on to the charterer many of the cost savingsrealized by his vessel. If on the other hand the probability of un-

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[16]The model can handle time-charters of any specified duration.

employment is greater than zero, then the owner will be more accommodating. In the latter case the normal spot rate over the life of the contract will be higher, if the owner is to earn 8% return on his investment. Always the base for negotiation is the average normal spot rate. The differentials are subtracted (variables X_1, X_2, X_3 and X_4) and added (variable X_5) to this base.

Our calculations include only two levels of certainty of employment but we can obtain as many as we wish. Taking the Persian Gulf-United Kingdom run, for an illustration, we notice that the time-charter rates under conditions of certainty range from $3.493 per ton of oil delivered for a vessel of 100,000 DWT to $1.933 for a 350,000 DWT vessel. If the certainty for full-time employment is only .75, however, the respective figures drop to $3.154 and $1.360. This is as compared to average normal spot rates of $6.017 for absolute certainty and $4.513 under .75 certainty of full-time employment. All rates as shown in the last column of Tables 9, 10 and 11 yield <u>at least</u> 8% return to the owners.

It is interesting to note how significant are the savings attributed to a liberal loan plan (X_4). For Run 1 (Persian Gulf-United Kingdom) we have to reach 300,000 DWT and beyond before size (X_1) overtakes X_4 in significance. For Run 2 (Caribbean-United Kingdom) the switch in positions occurs at 250,000 DWT. For Run 3 (Persian Gulf-Japan) because we assumed that the marginal vessels are larger, both at t_o and t_{15}, the economies of size as reflected in X_1 are not as significant as in Runs 1 and 2 but still only second to the liberal loan savings.

Third in terms of significance is the impact of the risk of unemployment (X_2), which in our case was based on .25 probability of unemployment, and then comes the "efficiency premium" (X_5). The "brokerage-fee saving" (X_3) is very insignificant and barely appears in the calculations.

Before leaving Tables 9, 10 and 11 we must make another observation. The only independent variable whose significance increases with size is the risk of underemployment. All the other impacts decrease, indicating that the cost of idleness per unit of capacity decreases with size. The greatest cost for the largest vessels appears to be underemployment.

III. Conclusions

The analysis of time-charter rates for the period of December 1959 to December 1966 shows that the conclusions reached in 1959 are still valid today. In most cases we can even make stronger statements now than we made then mainly because of the greater range in the size of tankers.

We have found that the break-even time-charter cost of the vessels chartered is the most reliable guide in the determination of time-charter rates. We cannot, therefore, speak about a well-defined level of time-charter rates. The structure of rates can be approximated, however, and it is expected to be greatly dispersed in the future depending on the size-composition of the fleet.

The spot rate exerts some influence on time-charter rates but such influence becomes very weak as the duration of the contracts increases. Under extremely high or depressed market conditions, the spot rate will undoubtedly

affect the time rates mainly through expectations. Even under these circumstances as the duration of the contract increases time-charter rates will converge asymptotically from both above and below to the relevant break-even time-charter rate.

Size and charter duration were found to be positively correlated, with the correlation becoming stronger as the level of marginal spot rates rises. Spot rates and charter duration were also found upon analysis to be positively correlated. However, the scarcity of large vessels at high rates, which forces charterers to charter smaller vessels, and the scarcity of small vessels at very low rates, becuase they are tied up, is reflected in the statistics and on the surface the averages show that both size and charter duration decrease as spot rates increase.

It appears that 8% return after taxes is close to the average cost of capital of tanker owners. Larger vessels, of course, earn more than 8% return, and during the period under study all vessels over 55,000 DWT earned on the average more than the market cost of capital.

The greatest threat to the largest vessels appears to be the risk of underemployment, due to the inflexibilities of size. This threat, however, is not expected to be as important in the future because a lot of the constraints (loading and unloading facilities, refining capacities, market sizes, etc.) which presently inhibit the most efficient utilization of these mammoths will be removed. We would expect, therefore, more of the economic advantages of larger vessels (as reflected in the underemployment variable X_1) to remain with the owner in the future. This, of course, only for those vessels which will not be

rendered marginal or affected extensively by shifts in the size composition of the tanker fleet.

We have observed that empirical evidence (obtained in Part I) shows that the ownership of the larger vessels may be relatively less risky. Now we have more corroborating evidence in data of Tables 9, 10 and 11 which show that the cost of idleness per unit of capacity decreases with size. This implies that not only are the larger vessels more efficient than the smaller ones given a particular run, but what is more they may be relatively more efficient if scheduled for the shorter runs. To be sure the total cost of idleness of larger vessels is greater, but to the extent that the probabilities of delays and idleness (by size of such) apply uniformly and independently to all vessels then, in certain cases the relevant criterion for minimization is the cost of delay per unit of potential capacity. If our data and calculations are correct, the largest tankers appear to be less intensive in terms of both capital and operating costs per unit of capacity than the smaller tankers. That is why, in cases where choice can be exercised, it may be better if the largest tankers are scheduled for the shortest runs where port idleness occupies a greater part of the potential capacity of a vessel. This may be seen also in the data of Tables 9 and 10 by comparing the rate ratios between the 350,000 and 150,000 DWT vessels for these two runs. The greatest improvement is observed in the Caribbean-United Kingdom run which is the shortest of the two. The calculations included in Table 11 are based on larger marginal vessels so in this respect there is no direct comparability between the Persian Gulf-Japan run and the other two.

Table 1

Selective List

Break-even Time Charter Rates

Size of Vessel DWT	Year Used as Basis for Costs 1959 S.C. 1959 O.C.	 1959 S.C. 1963 O.C.	 1963 S.C. 1964 O.C.	 1964 S.C. 1964 O.C.	 1966 S.C. 1966 O.C.
20,000	$3.48	3.18	2.99	2.92	2.92
30,000	2.93	2.62	2.38	2.29	2.29
40,000	2.64	2.28	2.02	1.95	1.95
50,000	2.44	2.03	1.75	1.73	1.73
60,000	2.31	1.87	1.58	1.56	1.56
70,000	2.21	1.76	1.47	1.43	1.43
80,000	2.13	1.70	1.40	1.34	1.34
90,000	2.09	1.66	1.35	1.27	1.27
100,000	2.05	1.62	1.31	1.24	1.24

Notes:

1. S.C. = Shipbuilding Cost

2. O.C. = Operating Cost

3. The calculations are based on the assumption that the: (a) vessel is used for 20 years normally employed (full-time) (b) applicable tax rate is 50% (c) depreciation is sum-of-the-years' digits method (d) owner borrows 80% at 6% per year for 8 years and (e) the cost of capital is 8%.

4. If the owner does not borrow and uses all equity capital the above rates yield approximately 5.6% return on investment rather than 8%.

Table 2

Correlation Matrix For Non-Log Analysis

	X_1	X_2	X_3	X_4	X_5	X_6
X_1 (size)	1.0000					
X_2 (marginal spot rate +100)	-.0076	1.0000				
X_3 (duration)	.4114*	.1269	1.0000			
X_4 (lead time)	.4032*	.0254	.6719*	1.0000		
X_5 (spot rate eq. of time charter)	-.7143*	.0985	-.2749*	-.2174*	1.0000	
X_6 (differential)	.5223*	-.0014	.2744*	.2545*	-.1733*	1.0000

* Indicates that correlation is significant at 98% confidence level (two-tail).

Variable	Mean	σ_X
X_1	50,292 DWT	27,918 DWT
X_2	53.47 (-46.53 INTA)	16.72
X_3	69.49 mo.	65.14
X_4	9.96 mo.	10.96
X_5	50.39 (-49.61 INTA)	8.9
X_6	-2.74%	10.59

Number of observations: 297

Table 3

Non-Log Formulation

X_5

Regression of X_5 on:

	R	R^2
X_1	.7143	.5102
X_1 , X_2	.7203	.5189
X_1 , X_2 , X_3	.7204	.5189
X_1 , X_2 , X_3 , X_4	.7257	.5267

$$X_5 = 59.04 - .0002X_1 + .0523X_2 - .0090X_3 + .0983X_4$$
$$(-.7351) \quad (.0982) \quad (-.0663) \quad (.1211)$$

X_6

Regression of X_6 on:

	R	R^2
X_1	.5222	.2727
X_1 , X_2	.5222	.2727
X_1 , X_2 , X_3	.5263	.2770
X_1 , X_2 , X_3 , X_4	.5264	.2771

$$X_6 = -12.75 + .0001X_1 - .0038X_2 + .0104X_3 + .0133X_4$$
$$(.4902) \quad (-.0061) \quad (.0642) \quad (.0137)$$

Notes: 1. Standardized coefficients in parentheses.

2. Of the regression coefficients only that of X_1 is significant (98% level). The rest are not significant even at the 95% level.

Table 4. Correlation Matrix for Log Analyses

	X_1	X_2	X_3	X_4	X_5	X_7	X_8
X_1 (size)	1.0000						
X_2 (marginal spot rate + 100)	-.1247	1.0000					
X_3 (duration)	.3696*	.0905	1.0000				
X_4 (lead)	.4664*	.0078	.6530*	1.0000			
X_5 (spot rate eq. of time charter	-.7930*	.0848	-.3299*	-.3105	1.0000		
X_7 (actual spot eq. + 100 / theoretical spot eq. + 100)	.6842*	-.0802	.1997*	.3423*	-.1930*	1.0000	
X_8 (actual spot eq. - theor. + 35.0)	.6681*	-.0589	.2759*	.3593*	-.2085*	.9241*	1.0000

*Indicates that correlation is significant at 98 per cent confidence level (two-tail.)

Table 5

Logarithmic Formulation

Regression of X_5 on:

	R	R^2
X_1	.7930	.6288
X_1, X_2	.7931	.6290
X_1, X_2, X_3	.7940	.6304
X_1, X_2, X_3, X_4	.8017	.6428

$$X_5 = 3.16 - .3075X_1 - .0041X_2 - .0219X_3 + .0222X_4$$

$$(-.8189) \quad (-.0070) \quad (-.1277) \quad (.1549)$$

The coefficients of X_1, X_3 and X_4 are significant (98 per cent level)

Regression of X_7 on:

X_1	.6842	.4682
X_1, X_2	.6842	.4682
X_1, X_2, X_3	.6867	.4716
X_1, X_2, X_3, X_4	.6907	.4771

$$X_7 = -1.3010 + .2788X_1 + .0097X_2 - .0226X_3 + .0160X_4$$

$$(.6830) \quad (.0151) \quad (-.1212) \quad (.1028)$$

Only the coefficient of X_1 is significant (98% level). Others are not significant even at 95% confidence level. The introduction of X_8 did not produce results significantly different from those of X_7 .

Table 6

Correlation Matrices for Analyses by Spot Rate Levels

I (< -57 INTA)

	X_1	X_2	X_3	X_4	X_5	X_6
X_1	1.0000					
X_2	-.3881	1.0000				
X_3	.1387	.0488	1.0000			
X_4	.0460	.3357	.5482	1.0000		
X_5	-.6570 (yes)	.2588 (yes)	.1850 (no)	.0876 (no)	1.0000	
X_6	.7074 (yes)	-.4473 (yes)	.1647 (no)	.0196 (no)	-.1446 (no)	1.0000

II (-57 to -32 INTA)

	X_1	X_2	X_3	X_4	X_5	X_6
X_1	1.0000					
X_2	-.0630	1.0000				
X_3	.5883	-.2040	1.0000			
X_4	.4456	-.2589	.5809	1.0000		
X_5	-.7495 (yes)	.0630 (no)	-.2803 (yes)	-.1013 (no)	1.0000	
X_6	.7780 (yes)	-.0534 (no)	.4145 (yes)	.3586 (yes)	.4117 (yes)	1.0000

III (> -32 INTA)

	X_1	X_2	X_3	X_4	X_5	X_6
X_1	1.0000					
X_2	-.0499	1.0000				
X_3	.6447	.2092	1.0000			
X_4	.5462	.0154	.8508	1.0000		
X_5	-.7655 (yes)	-.2040 (no)	-.7406 (yes)	-.6838 (yes)	1.0000	
X_6	.4262 (yes)	-.1834 (no)	-.0067 (no)	-.0330 (no)	.1820 (no)	1.0000

Table 7

Correlation Matrix for Analyses by Vessel Size

I (< 40,000 DWT)

	X_1	X_2	X_3	X_4	X_5	X_6
X_1	1.0000					
X_2	-.1378	1.0000				
X_3	.2323	-.1951	1.0000			
X_4	.2007	-.1804	.4643	1.0000		
X_5	-.4373 (yes)	.3365 (yes)	-.0094 (no)	.0326 (no)	1.0000	
X_6	.4127 (yes)	.2381 (yes)	.1016 (no)	.1154 (no)	.4916 (yes)	1.0000

II (≥ 40,000 DWT)

	X_1	X_2	X_3	X_4	X_5	X_6
X_1	1.0000					
X_2	-.0900	1.0000				
X_3	.1140	-.0898	1.0000			
X_4	.0659	-.1115	.5769	1.0000		
X_5	-.5896 (yes)	-.1058 (no)	.1252 (no)	.1057 (no)	1.0000	
X_6	.4938 (yes)	-.1159 (no)	-.0834 (no)	-.1567 (no)	+.0768 (no)	1.0000

Table 8

Stratification by Rate Level

Variable	< 43 (i.e. Below INTA less 57) Low Rate Period		43 to 68 Medium Rate Period		68 and Over High Rate Perio	
	Mean	σ_X	Mean	σ_X	Mean	σ_X
X_1	54,355	21,506	45.210	18,314	46.94	24,015
X_2	36.30	4.26	55.75	5.74	87.23	10.47
X_3	87.58	83.57	69.31	57.40	49.71	55.62
X_4	13.52	13.52	8.67	9.74	7.00	8.24
X_5	50.26	6.26	50.69	6.95	55.55	11.60
X_6	-.598	10.05	-4.73	9.96	1.82	10.33
# of transactions	103		136		25	

Stratification by Size

Variable	Under 40,000 DWT		40,000 DWT & Over	
	Mean	σ_X	Mean	σ_X
X_1	30,037	6,144	62,224	16,468
X_2	54.5	15.51	48.6	15.53
X_3	42.1	33.92	97.5	78.68
X_4	6.3	9.54	13.3	11.95
X_5	55.8	6.55	47.6	5.93
X_6	-10.95%	9.20	3.41%	6.03
# of transactions	109		155	

Table 9

Run: Persian Gulf-United Kingdom

Size of Chartered Vessel	Marginal Vessel at t_o	Marginal Vessel at $t_{n=15}$	Normal Spot Rate at t_o	Average Normal Spot Rate During Charter Period	$-X_1$	$-X_2$	$-X_3$	$-X_4$	$+X_5$	Spot Equivalent of Charter Rate
100,000*(a)	45,000	100,000	8.246	6.017	.512	1.175	.000	2.160	.984	3.154
(b)	"	"	6.184	4.513	.384	.000	.000	1.620	.984	3.493
150,000 (a)	"	"	8.246	6.017	1.498	1.213	.001	2.501	1.071	1.876
(b)	"	"	6.184	4.513	1.124	.000	.001	1.876	1.071	2.584
200,000 (a)	"	"	8.246	6.017	1.820	1.131	.001	2.373	.958	1.650
(b)	"	"	6.184	4.513	1.365	.000	.001	1.780	.958	2.325
250,000 (a)	"	"	8.246	6.017	2.068	1.066	.001	2.256	.883	1.510
(b)	"	"	6.184	4.513	1.551	.000	.002	1.692	.883	2.152
300,000 (a)	"	"	8.246	6.017	2.270	1.011	.002	2.146	.868	1.456
(b)	"	"	6.184	4.513	1.703	.000	.003	1.609	.868	2.066
350,000 (a)	"	"	8.246	6.017	2.471	.955	.003	2.025	.796	1.360
(b)	"	"	6.184	4.513	1.853	.000	.004	1.519	.796	1.933

*Loaded around the Cape; through Suez in ballast

Note: (a) Data for .75 certainty of full employment
(b) Data for 1.00 certainty of full employment
X_1 = Risk of Underemployment, Spot Equivalent
X_2 = Risk of Unemployment, Spot Equivalent
X_3 = Brokerage Fee Savings, Spot Equivalent
X_4 = Liberal Loan Terms, Spot Equivalent
X_5 = Efficiency Premium, Spot Equivalent

Table 10

Run: Car-U.K. 15-yr. Charter

Chartered Vessel	Marginal to	Marginal n=15	Normal Spot Rate	R_s Average Normal During Charter Period	$-X_1$	$-X_2$	$-X_3$	$-X_4$	$+X_5$	Spot Equivalent Long Term Rate
100,000 (a)	45,000	100,000	4.422	2.414	.448	.524	.000	1.013	.444	.872
(b)	"	"	3.316	1.811	.336	.000	.000	.760	.444	1.158
150,000 (a)	"	"	4.422	2.414	.695	.468	.000	.938	.378	.690
(b)	"	"	3.316	1.811	.521	.000	.000	.703	.378	.963
200,000 (a)	"	"	4.422	2.414	.831	.438	.000	.894	.340	.591
(b)	"	"	3.316	1.811	.623	.000	.000	.671	.340	.856
250,000 (a)	"	"	4.422	2.414	.940	.413	.000	.853	.315	.522
(b)	"	"	3.316	1.811	.705	.000	.001	.640	.315	.780
300,000 (a)	"	"	4.422	2.414	1.036	.392	.001	.812	.310	.483
(b)	"	"	3.316	1.811	.777	.000	.001	.609	.310	.733
350,000 (a)	"	"	4.422	2.414	1.129	.371	.001	.769	.286	.430
(b)	"	"	3.316	1.811	.847	.000	.002	.577	.286	.671

Note: (a) Data for .75 certainty of full employment
(b) Data for 1.00 certainty of full employment

X_1 =
X_2 =
X_3 =
X_4 =
X_5 =

For description of symbols and variables see Table 9

Table 11

Run: Persian Gulf-Japan

Size of Chartered Vessel	Marginal Vessel at t_o	Marginal Vessel at $t_{n=15}$	Normal Spot Rate at t_o	Average Normal Spot Rate During Charter Period	$-X_1$	$-X_2$	$-X_3$	$-X_4$	$+X_5$	Spot Equivalent of Charter Rate
150,000 (a)	70,000	150,000	5.430	3.456	.412	.706	.000	1.436	.599	1.501
(b)	"	"	4.073	2.592	.309	.000	.000	1.077	.599	1.804
200,000 (a)	"	"	5.430	3.456	.618	.660	.000	1.367	.538	1.348
(b)	"	"	4.073	2.592	.463	.000	.001	1.025	.538	1.640
250,000 (a)	"	"	5.430	3.456	.785	.662	.001	1.303	.497	1.242
(b)	"	"	4.073	2.592	.589	.000	.001	.977	.497	1.522
300,000 (a)	"	"	5.430	3.456	.930	.590	.001	1.240	.488	1.183
(b)	"	"	4.073	2.592	.697	.000	.001	.930	.488	1.452
350,000 (a)	"	"	5.430	3.456	1.072	.559	.001	1.172	.450	1.100
(b)	"	"	4.073	2.592	.804	.000	.002	.879	.450	1.356

Note: (a) Data for .75 certainty of full employment
(b) Data for 1.00 certainty of full employment

X_1 =
X_2 =
X_3 =
X_4 =
X_5 =

For description of symbols and variables see Table 9

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